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The Wheat-Head Army-Worm as a Timothy pest

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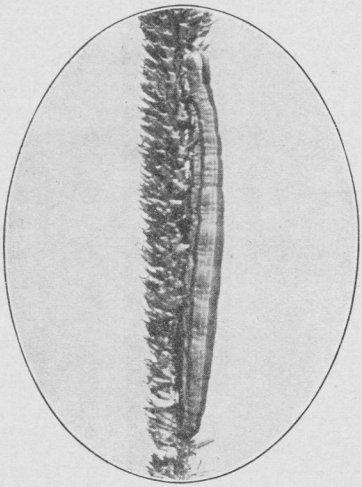
BULLETIN 122 FEBRUARY, 1911

The Wheat-Head Army-Worm as a Timothy Pest



IOWA STATE COLLEGE
OF AGRICULTURE AND MECHANIC ARTS

AGRICULTURAL EXPERIMENT STATION

AMES, IOWA

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SUMMARY

1. The wheat-head army-worm, when full grown, is a smooth, greenish or brownish striped caterpillar, something over an inch long, which feeds on the heads of timothy and some of the small grains. The injury is mostly to the timothy seed crop. Page 326.

2. The caterpillars eat the seeds and allow the chaff to fall to the ground. They eat one or both sides of a head, sometimes leaving nothing but the stem. This injury is shown on the front page of this bulletin Page 325.

3. The caterpillars prefer timothy to anything else. It is only when they are extremely abundant that they go to the small grains. Page 325.

4. The wheat-head army-worms are at work twice during the year: first, from late in May until well into July; second, from the middle of August until frost. Page 327.

5. The first brood feeds mostly on timothy. The second brood feeds on timothy whenever the caterpillars can get it, otherwise they feed on many of the common wild grasses, such as foxtail, red top, etc. Page 327.

6. The eggs, from which these caterpillars hatch are laid by a yellow-brown moth, which is about 1½ inches across the outstretched wings. Page 327.

7. The full grown caterpillars go into the soil and transform to the pupa stage, a resting stage. From the pupa comes the yellow-brown moth, thus completing the life cycle. Page 327.

8. Early cutting of badly infested fields will starve out some of the caterpillars. In some cases this early cutting may be necessary in order to save the crop. Page 328.

9. Keeping the wild grasses cut along the roadsides and fence corners reduces the number of insects by cutting off their food supply. Page 328.

10. Early fall plowing will bury the half grown caterpillars in meadows where they have been common earlier in the year. This should be done before September 15. Page 328.

11. Early fall pasturing, before the middle of September is the best remedy we have found for the wheat-head army-worms. It will throw the second brood caterpillars out of food, and the pastured meadow will have fewer wheat-head army-worms the next year. Where clover and timothy are grown together, this treatment would allow some chance for growth after the middle of September, so that the clover would be less susceptible to injury during the winter. Page 329.

12. Farmers will do well to examine their meadows closely this year for the wheat-head army-worm. If the insect is at all common, steps should be taken to prevent any further damage the next year. Page 329.

THE WHEAT-HEAD ARMY-WORM AS A TIMOTHY PEST

Meliana albilinea Hbn.

By R. L. Webster

INTRODUCTION

RECENT INJURY TO TIMOTHY

Injured timothy heads, eaten by the wheat-head army-worm, have been more or less common in Iowa meadows for several years. This damage is usually noticed about haying time. In the summer of 1910 this insect became very abundant in the northern half of the state and caused a large amount of damage. The worst damage was reported from Pocahontas, Dickinson, Clay, Hancock, and Worth counties, but the area in which timothy was seriously injured extended as far south as Story county. However, the caterpillars, or larvæ, as we will call them, were found in greater or less numbers all over the state. In some localities 50 to 90 per cent of the timothy heads in certain fields were injured.

Since the larvæ feed mostly on timothy heads the damage is mainly to the seed crop, although occasionally the hay crop may be considerably affected. Great damage has been done in the past by this insect and it undoubtedly will cause damage in the future. In the hope of finding means of control for this pest and thereby reducing the injury, the study of the insect was taken up.

APPEARANCE OF THE INJURY

These larvæ gnaw into the heads of timothy, wheat, rye and other small grains, and even some of the wild grasses, but they seem to prefer timothy to anything else. Such injury is shown in figure 1. The caterpillars feed on the seed and allow the chaff to fall to the ground. Frequently the larvæ may be seen working in the head, as shown in figure 2, or resting on the stem just below the head. They begin to feed at the bottom of the head and work upward, sometimes eating only one side, or even less than that, sometimes taking practically all but the stem. Badly injured fields appear dry and brown in July, and the denuded timothy heads are conspicuous, even at some little distance.

FIGURE 1. TIMOTHY HEADS INJURED BY THE WHEAT-HEAD ARMY-WORM

THE INSECT'S APPEARANCE

The full grown caterpillars, or larvæ, are something over an inch long, brownish or greenish in color, usually with distinct stripes. There is much variation. Some are quite green, others are decidedly brownish in color. Usually there is a distinct dark stripe down the back, another at the side, with a pale yellow or white line just below it. The full grown larva is shown in figures 2 and 13.

The wheat-head army-worm differs in several ways from the true army-worm. So far as habits are concerned it is different in that it feeds on a lesser variety of plants and in that it has a decided preference for the heads of various grains and grasses.

When the caterpillar attains its full size it stops feeding and goes into the soil, forms a loose earthen cell and therein changes

to the inactive pupa form. This pupa is the resting stage, which comes between the caterpillar and the adult moth. The pupa is a dark brown object, about half an inch long. It is shown in figure 4. From this pupa the parent moth emerges. The two sexes then mate, and the females deposit their eggs for the next generation of larvæ. The moths are about 1½ inches across the outstretched wings, and yellow-brown in color. The moth is shown in figure 5.

TIME OF APPEARANCE OF THE GENERATIONS

In the spring the moths emerge from the pupæ and deposit their eggs. These eggs hatch towards the latter part of May and the tiny young larvæ begin to feed, first on the tender green leaves of the young timothy plants, later on the heads. By the first of July some of the caterpillars are full grown, although they are common until about the middle of that month. The mature larvæ go into the soil, change to pupæ, and the brownish moths appear again in August. These moths lay their eggs and the young wheat-head army-worms appear in the fields for the second time about the middle of August.

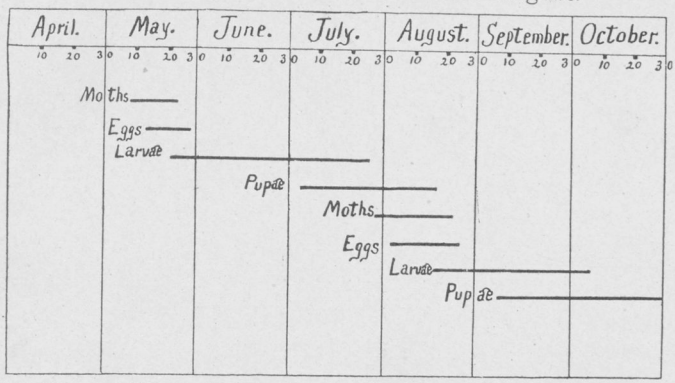


FIGURE 3. DIAGRAM OF THE LIFE CYCLE

These late larvæ prefer to feed on timothy heads, but as these become few late in the season, the caterpillars readily eat the ordinarily abundant foxtail, red top, and some of the common wild grasses. When they mature late in the fall the larvæ go to the ground as before and transform to the pupa stage, remaining in that stage until the next spring.

CONTROL MEASURES

Usually the injury to timothy is not noticed until considerable damage is done in June or July. The only

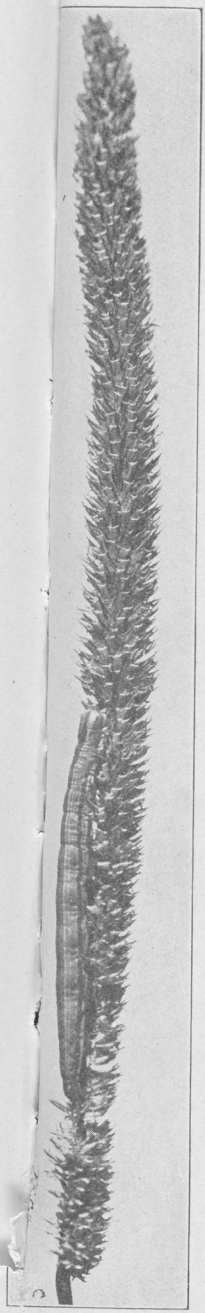


FIGURE 2. A WHEAT-HEAD ARMY-WORM ON A TIMOTHY HEAD. ENLARGED

advisable remedy at that time is to cut the field at once, and so destroy or starve out at least a part of the larvæ. Indeed, it may be necessary to cut at once in order to get anything at all. Outside of this there are no direct measures. The farmer can only take steps to prevent further damage the next year.

CLEAN CULTURE

Since the wheat-head army-worms, especially those of the second brood, are able to feed largely on some of the common wild grasses, as foxtail, etc., the presence of those grasses in meadows is a direct aid to the pest. The cleaner the farmer's fields, roadsides, and fence rows, the freer his timothy is likely to be of the wheat-head army-worm. A whole field may be stocked with these insects from those which breed along the fences, both on the volunteer timothy and on the wild grasses.

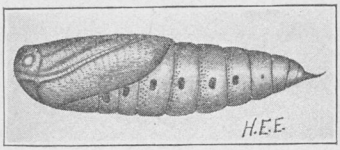


FIGURE 4. THE PUPA. ENLARGED THREE TIMES

FALL PLOWING

This insect was first known as a wheat insect, and late fall plowing and harrowing was proposed as a protective measure. The idea was to disturb and break up the cocoons and pupæ, killing the insect in that way. A much better measure would be to plow infested fields early in the fall, when the second brood larvæ are not more than half grown. During the first two weeks of September the larvæ are at work on timothy plants, as well as on foxtail and other grasses, in the field. Sod that is turned under at this time would effectively bury and kill the young wheat-head army-worms. Any that might escape would find nothing to eat. This measure, it will be seen, only reduces the number of the insects for the following year. It is "locking the door after the horse is stolen."

If it is impracticable to turn under a meadow in the fall, or if the meadow is to be kept for another year, a measure such as early fall pasturing would be advisable.

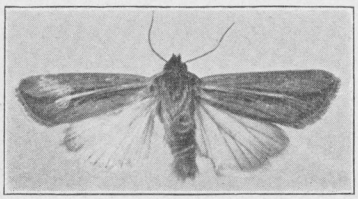


FIGURE 5. THE MOTH. SLIGHTLY ENLARGED

EARLY FALL PASTURING

In the summer of 1909 it was found that pastured meadows were often less injured than those which were not pastured. This was first noticed at Dexter, Iowa, when Mr. James Boot and the writer examined several injured fields. Counts in meadows on the Boot farm showed that about 15 per cent of the timothy heads were injured. In an adjoining field, which had been heavily pastured all the previous year, the damage was 5½ per cent.

These observations brought out the idea that fall pasturing of infested meadows might reduce the injury caused by the wheat-head army-worm. Since the young second brood caterpillars are at work in meadows from the middle of August on, rather close pasturing early in the fall would keep the grass down so well that these larvæ would be starved out. Doubtless many timothy stems containing eggs would be eaten, eggs and all, and probably some of the young larvæ would share the same fate.

Late spring pasturing would have the same effect, but the eggs and young larvæ do not appear on the timothy plants until the latter part of May, too late for pasturing, if hay is to be cut from the field.

Observations and counts made in the years 1909 and 1910 have shown that early fall pasturing does reduce the injury. These notes were made mostly at four places in the state, at Woodburn, Dexter, Humeston, and Ames. In the counts usually 500 or more timothy heads were taken at random, keeping track of the number that showed injury by the wheat-head army-worm. A general account of these observations is given in the following pages.

OBSERVATIONS AT WOODBURN

Woodburn is a small town in Clarke county, in southern Iowa. The wheat-head army-worm was reported from this place in 1909 by Mr. C. B. McDonough, a well informed farmer living in Woodburn.

On June 24-25, 1910, I visited Woodburn and made a number of counts of injured timothy heads in meadows there. In a two year old meadow on the McDonough farm 20 per cent of the timothy heads had been injured. This meadow had never been pastured. Not far from this field, on the farm of G. A. Marquis, was a four year old meadow, which also had never been pastured. 20.6 per cent of the heads were injured in this field. Five hundred heads were counted in each case.

Counts were then made in a 40 acre meadow, eight or ten years old, belonging to J. A. Mason. This had been pastured in the spring and fall of every year and this year it was pastured until the latter part of May. In spite of the late spring pasturing there was a fair stand of timothy and the counts showed a very

low percentage of injury by the wheat-head army-worm. Of 1,500 heads counted there was 3.6 per cent injury in the lower part of the field, 8.6 per cent in the middle and 6.2 per cent in the upper part, an average of 6.1 per cent for the whole field.

In another 40 acre meadow on the Maggie McClure estate there was an average of 3.6 per cent injured heads. This was pastured only in the fall of the previous year, not at all in the spring.

A large field on the Jacob Shively place showed an average of 10.8 per cent injured heads. Part of the field was one year old, part of it two years old. It had been only lightly pastured, a fact which probably accounts for the larger amount of injury. Another field on the Shively place was injured to the extent of 8.2 per cent. This was a three year old meadow and had been pastured rather heavily. The injury was more than usual for a pastured field in this locality, but not nearly that for an unpastured field.

One thousand timothy heads were counted in a 40 acre field on the Henry Garris estate, near the McDonough farm. This meadow was 3 years old, and it had been accidentally burned over in the spring of 1908 and also in the spring of 1910. It had not been pastured since the spring of 1909. Here 21.1 per cent of the heads were injured. The field was burned over early in the spring, before the moths would have a chance to emerge, so that there could be no effect on the insect from that source.

OBSERVATIONS AT DEXTER

The town of Dexter is in the southwestern corner of Dallas county, about 35 miles west of Des Moines. The injury by this insect was reported from Dexter in 1908.

Several counts were made in meadows on the James Boot farm, just north of Dexter, on July 15, 1909. In a one year old field 12 per cent of the heads were injured; a four year old field was injured to the extent of 17 per cent. Both of these meadows were not pastured. In a ten year old field, pastured all of the previous year, but not that spring, the injury was 5½ per cent.

The injury the next year, in these same fields, was about in the same proportions.

On July 16, 1909, I made a count of injured timothy heads in a clover and timothy field on the O. S. Neal farm, west of Dexter. It was the first crop of timothy on the field. At this time 28.6 per cent of the heads were injured, in a count of 500 heads. That fall the field was heavily pastured for four months, but it was not pastured the next spring. The larger part of it was plowed in the spring and put into corn. On July 1, 1910, I made another count in this field and found only 10.2 per cent of the heads were injured. This shows a great reduction of injury, apparently due to the fall pasturing. But the greater part of the field

had been turned under that spring. The moths that emerged from the whole field, then, would deposit their eggs in the timothy that remained. Had the whole field been left unplowed, the average injury in 1910 would doubtless have been much less than 10.2 per cent.

Across the road from this field, on the Charles Fisher place, was a meadow about eight years old, pastured fairly close the previous fall and also in the spring until about the 15th of April. Of 500 heads counted here 3.2 per cent were injured.

OBSERVATIONS AT HUMESTON

About Humeston, in the northwestern corner of Wayne county, is a large area devoted to the raising of timothy seed. Farmers about Humeston tell me that the "timothy worms," as they are called, sometimes become very destructive there, causing great damage to the seed crop.

In July, 1910, the writer examined timothy fields in the vicinity of Humeston and made counts of injured heads. In no case, however, was much damage being done. On account of the small amount of injury, differences between fields did not show sharp contrasts.

Several counts were made in meadows on the I. C. Morford farm east of Humeston, July 12, 1910. A one year old meadow, unpastured, had 9.2 per cent injured heads. Near it was a two year old field, also unpastured, which had 8.8 per cent of the heads injured, the average from 1,000 heads counted. On the same farm was a pastured meadow, part of it three years old, part of it five years old. Of 1,000 heads counted here 4.9 per cent were injured. This field had been pastured in the fall and late in the spring. Because of the small infestation there was not a striking difference between the fields, but the lighter infestation was in the pastured field.

On the farm of Dr. George McCollough, just south of the town, was a piece of timothy of about 46 acres. This field had been in timothy for the last 18 years. The previous fall it was pastured rather closely from the last of September on. One thousand heads in this field were counted and only 2 per cent of them were damaged. In a 10 acre meadow on the same farm, not far from the first field, another count of 1,000 heads was made, showing 5.2 per cent injured heads. This field was pastured from the first of December on, too late to have any effect on the wheat-head army-worms, and it was not pastured at all in the spring. Here again is only a small average amount of injury, with the difference in favor of the field pastured in the fall.

Counts were made in several other fields south of Humeston all of which had been pastured late in the fall and all showed an

average of about 6 per cent injured heads. This late pasturing, however, did not begin until October or November, too late to have much effect on the wheat-head army-worm. Some of the late straggling larvæ may have been affected in October, but the most of them would have gone into the soil by that time.

OBSERVATIONS AT AMES

Two timothy fields on the Daniel McCarthy farm south of the college at Ames served as excellent places for observations on this insect during 1909 and 1910.

All of one field, 40 acres, was in timothy in 1909. Half of it was turned under in 1910 and planted to small grain. It was very lightly pastured in the fall of 1909, but evidently not enough to affect the wheat-head army-worms. Five hundred timothy heads were counted in this field July 21, 1909, and 17.2 per cent injured heads were found then. In 1910 there was 37 per cent of injury June 25, and on July 19 this had increased to 49 per cent.

The hay was cut July 25, and in August many eggs and young larvæ of the second generation were found in the field. Between September 6 and 10, six horses and seven cows were turned on the field. The horses kept to the timothy in feeding, but the cows ate largely in the stubble of the small grain. By September 20 the grass was eaten down fairly well, but a few caterpillars were still at work. On October 4 I compared this field with the second field, which had been badly infested both years, but which was not pastured that fall, and I found an amazing contrast between the two. I could find no larvæ in the pastured field as I walked through it, but in the other field they were very common on the second growth of timothy. Practically all of the new green heads were more or less eaten by the wheat-head army-worms. This second growth had been kept well eaten down in the pastured field. Later observations showed the same condition; no larvæ in the one field, and injured timothy heads and plenty of larvæ in the other. This was the most striking instance of the value of early fall pasturing that was met with in the two years study of this insect.

Other observations, made in September, 1910, in the northern part of the state, where the damage had been so severe, showed that it was usually the unpastured fields that suffered the most.

Older meadows were not more injured, as a rule, than younger fields. In an 18 year old timothy field there was one of the least percentages of injury recorded, 2 per cent in the McCollough field at Humeston. Again, one year old fields frequently showed high percentages of injury.

PAST HISTORY, DESTRUCTIVENESS AND DISTRIBUTION

PAST HISTORY IN IOWA

During 1887 and 1888 a large amount of damage was caused by the wheat-head army-worm to the timothy seed crop in southeastern Iowa. Again in 1893 Professor Osborn recorded much injury to timothy, especially around Dubuque, and from there west to about the middle of the state. The larvæ have been noticed commonly over the state during the past few years and in 1910 caused a great amount of damage to timothy in the northern half of the state.

PAST HISTORY IN OTHER STATES

According to Doctor Riley the first record of injury caused by this insect was in 1872, when it was found damaging oat heads in Huntington county, Pennsylvania. In 1875 Doctor Lintner wrote of the damage to wheat in New York state. Riley recorded serious injury to wheat in Kansas in 1876. Doctor Lintner in 1893 reported the insect causing damage to rye in New York and in 1896 he recorded injury to barley. In 1893 M. H. Beckwith said that the species had injured timothy in Delaware and Doctor J. B. Smith reported it as injurious in New Jersey the same year. My father, F. M. Webster, writes me that this insect became very abundant in northeastern New Mexico in 1909, where it fed on oats and wheat in great numbers.

The 1910 outbreak, which was quite severe in Iowa, extended into Minnesota and eastern South Dakota, according to reports I have had from those states.

DESTRUCTIVENESS

In 1876 the wheat-head army-worm caused much alarm in Kansas, where it devastated wheat fields and did a great amount of damage. During 1887 and 1888 the ravages of the insect to timothy became most serious in southeastern Iowa. Professor Osborn estimated that the loss to the timothy seed crop in Iowa in 1887 amounted to half a million dollars.

DISTRIBUTION

Although the species was first noticed by European writers, it is not known to occur outside of America. To the north the moth has been found from Novia Scotia to Alberta (Wooley Dod), to the east in Delaware and New Jersey, to the west at Glenwood Springs, Colo., (Barnes), and southern Arizona (Barnes). According to Sir George F. Hampson the species occurs at Mexico City, Mexico; Coquimbo and Mulchen, Chili; and Florenzia, Argentine. Buenos Ayres, Argentine, was given as the source of Hübner's material.

FOOD PLANTS

Previously this insect had been recorded from most of the small grains, as the following list indicates: wheat, timothy, barley (Lintner) rye, oats (Riley) sweet corn, sorghum (Miss Murtfeldt) wild rice (Chittenden) Indian corn (Forbes). The grass feeding habits of the larvæ had been noticed by Riley, Osborn and Smith, but I have found no records of any particular grasses as food plants. In the Iowa work the following grasses were found to be eaten, either the heads or the leaves being affected, or both. These were *Andropogon furcatus* (blue stem), *Sorghastrum nutans* (Indian grass), *Echinochloa crusgalli* (barnyard grass), *Setaria glauca* (yellow foxtail), *Setaria viridis* (green foxtail), *Calamagrostis canadensis* (red top), *Agropyron caninum* (awned wheat grass), *Agropyron* sp., and *Hordeum jubatum* (squirrel tail grass). Eggs have been found in the sheath of speltz and *Elymus robustus* (robust lyme grass). These are probably also food plants of the larvæ.

Of these grasses, the foxtail, both the green and the yellow, are the most common in fields, and the larvæ feed mostly on these. The green foxtail was found to be preferred to the yellow, both in the field and in the insectary.

Larvæ were placed on a number of other plants in the insectary to determine whether or not they would feed on those plants. Mr. McCall placed larvæ on orchard grass, *Dactylis glomerata*, and they ate freely of the heads. Mr. H. E. Ewing had the same experience with quack grass and *Bromus inermis* (Hungarian brome grass). Larvæ were also tried on crab grass and bluegrass. They would eat slightly at the heads of the crab grass but not freely. Some young larvæ were placed on bluegrass, but they escaped from the cage without touching the heads. Bluegrass has ripened and dried by the time the young larvæ are old enough to feed on grass heads, so they may never touch it on that account.

Red clover, white clover, sweet clover and smartweed were also offered to the larvæ, but they refused them, preferring to starve instead. Mr. McCall offered heads of barnyard grass to larvæ in the insectary, but they refused to eat them. The writer has found young caterpillars feeding down in the sheath of this grass and slightly on the head, where it was still inside the sheath, but the grass is evidently not attractive to the larvæ.

The larvæ always preferred timothy to anything else. Only where they were extremely abundant did they attack the small grains. Mr. C. B. Gray, a farmer living near Corwith, Iowa, tells me that the caterpillars attacked oats to some extent near there in 1910. However, on the Daniel McCarthy farm at Ames, where the damage was severe on timothy, we could find no larvæ on the small grain adjoining.

CLASSIFICATION

SYNONYMY

The moth of the wheat-head army-worm was first described in 1823 by Jacob Hübner.* In 1816 Hübner gave the name *Leucania albilinea* in his Verzeichniss bekannter Schmettlinge,** but without a description, and he here referred to the figures in the Zuträge, which was not published until later. The original description in the Zuträge is decidedly brief, and without the excellent figure, the species would hardly be recognizable.

The validity of Hübner's names was a much disputed question some thirty years ago and these names were not accepted by many entomologists on account of the very poor and inadequate descriptions that went with them. But his figures were very good, and because of this many of Hübner's names have been generally accepted.

In 1852 M. A. Guenée described the moth, giving it the same specific name, *albilinea*.*** Consequently the name of Guenée is sometimes given as the authority for the species.

Since these early writings the moth has been described no less than seven times, with as many different names. As the species varies greatly, and has a wide distribution, there was some cause for the extensive synonymy. The references to the descriptions of these synonyms may be found in the bibliography at the end of this bulletin. The synonymy of the species, according to Sir George F. Hampson, is as follows:****

albilinea Hübner, 1823.
diffusa Walker, 1856.
moderata Walker, 1856.
harveyi Grote, 1873.
chilensis Butler, 1882.
obscurior Smith, 1902.
tetera Smith, 1902.
neptis Smith, 1902.

These specific names have been used in connection with the generic terms Leucania and Heliophila. Sir George F. Hampson places the species in the genus Meliana.

Dr. J. B. Smith has examined most of the moths reared by us in the Iowa work and he writes me that these are all the species *diffusa* Walker, which he considers distinct from *albilinea* Hüb-

* Zuträge zur Sammlung exotischer Schmettlinge. Zweytes hundert. p. 25. No. 169. Figs. 337, 338.

** Verzeichniss bekannter Schmettlinge. p. 241.

*** Histoire naturelle des insectes. Species Genérál des Lépidoptères. Noctuélites I. p. 89.

**** Catalogue of the Lepidoptera Phalænæ in the British Museum, vol. 5, p. 283.

ner. Later investigations may show that more than one species are here concerned.

COMMON NAME

So far as I am aware this species has been known under but a single common name; the wheat-head army-worm. The first record of serious injury was the damage to wheat heads, although the insect undoubtedly causes more damage to timothy heads than to wheat heads. The name "wheat-head army-worm" has been adopted for use by the American Association of Economic Entomologists.

LIFE HISTORY

There are two distinct generations of the wheat-head army-worm in Iowa. Their time of appearance in general was given on page 327. The appearance of the various stages in the year is here recorded in detail.

No moths were seen in the spring of the two years the wheat-head army-worm was studied, and the first trace of the insect in the spring was the finding of young larvæ and eggs in May, 1910. A single first stage larva was found at Ames, May 20. At Dexter May 28 both eggs and larvæ were found commonly. At Ames June 6 larvæ were very common, in stages I, II and III. By June 30 at Ames the injury had reached its height in infested timothy fields. The full grown larvæ, stage VII, appeared to be the most abundant of all the stages at this time. By July 13, (1909), larvæ were becoming rare. A few were found July 21, (1910). The last record of the first brood larvæ is July 29, when two were found along a roadside near Ames.

In the insectary the first pupa was found July 3, and the insectary notes show that larvæ pupated all through that month. The first moth emerged in the insectary July 29, and they continued to emerge until August 26, the last record. Most of them emerged from August 1 to 18. They were found common in the field as early as August 6.

In the field a few young larvæ of the second generation were found first August 16. Some days later they became very numerous. In the insectary eggs were found as early as August 8. Outside, at Ames, eggs were found very common August 20, in the sheath of timothy plants. By August 27 stages I, II, III and IV of the larvæ were found, but stage IV was not common. On September 10 stages I to V inclusive were found, all on timothy plants. At Spencer, Iowa, September 14, a number of mature larvæ were found. Larvæ were common about Ames as late as October 15. Pupæ were found in the insectary from the first of October on.

A few of the late first brood larvæ, brought in when they were becoming rare, pupated, but the moths did not emerge that sea-

son. Larvæ collected July 14 and 21 wintered in the pupa stage. Other larvæ collected July 29, went into the soil August 3, and spent the winter as pupæ. This occurred, however, only with some of the late straggling larvæ of the first brood.

THE EGG

Doctor Riley said that the eggs of this insect were deposited in the sheath of those plants on which the larvæ were to feed. In the spring of 1910 I began to look for eggs in the sheath of timothy plants and spent several days in southern Iowa in the search, examining hundreds of plants. Finally in a badly infested meadow at Dexter I found eggs down on the crown of timothy plants, tucked securely away under small pieces of dead leaves. This position is shown in figure 6. Riley found the eggs within the sheath in the summer, but it is evident that he had not seen them in the spring. In not a single case did I find eggs elsewhere than on the crown of timothy plants in the spring.

In August, after the moths had appeared, we began to search

FIGURE 6. EGGS AT BASE OF TIMOTHY PLANT. ENLARGED

again for eggs on timothy plants in meadows, first looking at the base of the plants. None were found there, and finally Mr. McCall took up a lone, dried timothy plant which had been missed in cutting, and found many eggs in the sheath of that plant. Thereafter the eggs could be found commonly in that position, such as is shown in figure 7. It was found that practically all of these dried timothy stems, which had been missed when the hay was cut, had eggs on them. Later, eggs were found on the young, green plants of the second growth.

FIGURE 7. EGGS IN THE SHEATH OF A TIMOTHY PLANT. SLIGHTLY ENLARGED

As Riley noted, the eggs are placed in single, double, and even triple rows. It was noticed that the eggs would adhere to each other, and whole rows would come out from the sheath easily when picked up.

Usually the eggs were found in the sheath just below the topmost blade. They were often found just below the second blade, however, and even below the third. Occasionally, on large timothy plants, eggs were found just below all three blades.

So far as I can determine no plants have ever been recorded on which the eggs are said to be deposited. Riley said that they were deposited on those grains on which the larvæ were to feed. In Iowa we have found eggs on the following plants: timothy, wheat, oats, speltz, *Andropogon furcatus* (blue stem), *Sorghastrum nutans* (Indian grass), *Echinochloa crusgalli* (barnyard grass), *Setaria viridis* (green foxtail), *Calamagrostis canadensis* (red top), *Agropyron caninum* (awned wheat grass), *Agropyron* sp., *Hordeum jubatum* (squirrel tail grass), and *Elymus robustus* (robust lyme grass). Doubtless eggs are deposited on the other small grains and on other grasses.

An average of about 70 eggs are deposited within the sheath of timothy plants. In a count of 20 depositions, made by Mr. T. M. McCall and the writer, the average of 69.9 eggs was obtained. The range was from 25 to 164 eggs.

No very accurate data was obtained regarding the number of eggs deposited by a single female. In one instance a male and a female were confined in an insectary cage by Mr. Ewing, and 55 eggs were deposited in three days. The male died at the end of the second day and the female died the third day. Of these, 49 were deposited in a single night, the second.

Riley said that the eggs hatch in 3 to 5 days. Our notes are not at all detailed, but they indicate that the eggs may hatch in

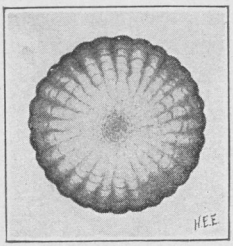


FIGURE 8. THE EGG. ENLARGED 40 TIMES

3 to 10 days. For instance, some freshly laid eggs were brought in from outside August 20 and these hatched in 3 and 4 days. Again eggs brought in August 24 hatched in 5, 7, and 8 days. Another lot, part of which were parasitized, hatched in 2, 3, 6, and 10 days.

Following is given a description of the egg.

Egg: Pale yellowish; sub-spherical, flattened above and below; width .61 mm. (average), depth about half the width; with rugosities forming ribs, which number 30 or more.

The eggs change to a slate bluish color before hatching.

THE LARVA

At first the newly hatched larva begins feeding on the epidermis within the sheath and on the leaves of the plant where it has

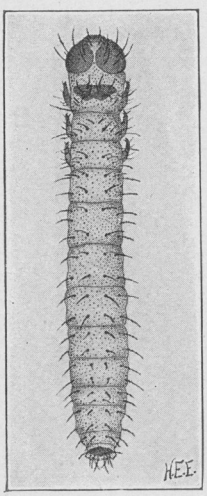


FIGURE 9. THE YOUNG LARVA. STAGE I. ENLARGED 30 TIMES

hatched. The feeding within the sheath causes this to become brown and dried, as is shown in figures 10 and 11. The browned sheath may be found commonly on timothy plants in the fall. On the blades the young larvæ eat out the epidermis in long narrow areas, shown in figure 12. Sometimes in young timothy

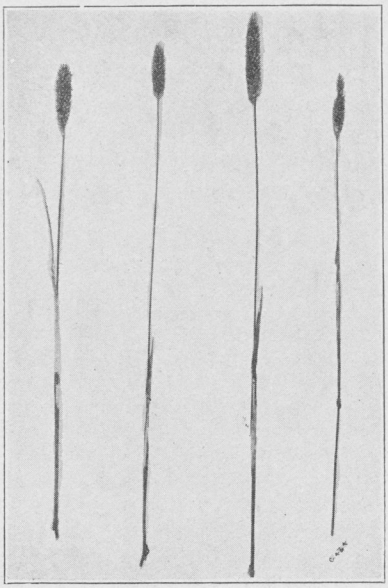


FIGURE 10. THE INJURY AT THE SHEATH OF TIMOTHY PLANTS

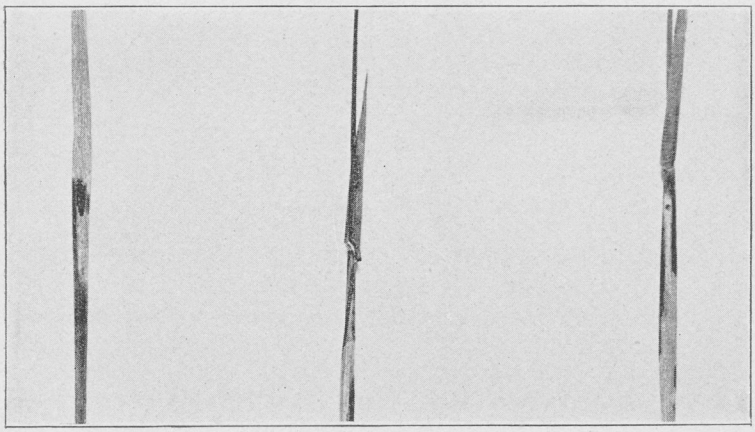


FIGURE 11. INJURED SHEATH OF TIMOTHY PLANTS. ENLARGED

plants they bore small holes through the tender unfolding blades. When the larva has reached the third or fourth stage it begins to feed on timothy heads or on some other grass heads. Occasionally these young larvæ may be seen stretched out at an oblique angle from the head, the caudal end upward, eating into the head. Later the larvæ feed lying along the stem, as shown in figure 2.

We found seven larval stages, as Riley noticed. Difficulty was encountered in keeping track of the stages, as the larvæ would eat their cast skins. Mr. Ewing observed this in the insectary. He first saw a fifth stage larva in the act of moulting, and coming back to it about 10 minutes later he found it eating the cast skin. The head only was left uneaten.

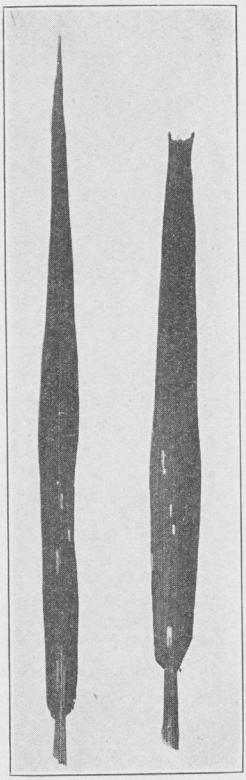


FIGURE 12. TIMOTHY LEAVES INJURED BY YOUNG LARVAE

Following is given descriptions of the seven larval stages.

Stage I.

Length about 1.9 mm. when first hatched; head width .26 mm. (average). General color dull yellowish; head, thoracic legs, and tips of prolegs black;

cervical shield dark brown; a black area at the caudal end of the larva on anal prolegs and just above them. First and second abdominal segments without prolegs. The larva loops when crawling. It is able to suspend itself by a silken thread when occasion demands.

Stage II.

Head width .39 mm. (average).

Head brown; cervical shield lighter, crossed by the pale median line. Dorsal line narrow, pale, edged with a broad brownish space; subdorsal broad, pale; lateral narrow, brownish; sublateral broad, pale; suprastigmatal space broad, brownish; ventral side of larva greenish.

Stage III.

Head width .65 mm. (average).

Head gamboge yellow, crossed by the lines from the body segments; cervical shield light brown, inconspicuous. The dark lines of the body are olivaceous, like those of state II. The looping habit is still in evidence.

Stage IV.

Head width .96 mm. (average).

Head honey-yellow, crossed by the brownish stripes from the body segments; cervical shield missing. The dark lines of the body are brownish, sometimes dull greenish; the dorsal and suprastigmatal dark spaces more than twice the width of the lateral dark space.

Stage V.

Head width 1.55 mm. (average).

General color greenish, with a pale yellow substigmatal space. Head dull greenish, with traces of the dark dorsal and lateral lines. Median dorsal line narrow, greenish, broadly dark edged; subdorsal pale, cut in two by a broad dark space; lateral broad, dark; sublateral line very narrow, pale; suprastigmatal space broad, dark; substigmatal space broad, subequal to suprastigmatal, pale yellowish.

Stage VI.

Head width 2.25 mm. (average).

Head dull green, with traces of the dark lines from the body, and also of the white substigmatal space. Sublateral line pale, nearly obsolete. Substigmatal space white, sometimes with reddish or cream tinges below.

Stage VII.

Length 25 to 35 mm. Head width 3.07 mm. (average).

General color brownish or greenish. Head greenish, with brown reticulations. Dorsal line narrow, pale, broadly brown edged; subdorsal space pale, cut in two by a broad dark band; lateral line dark, edged below with a broad brownish space; sublateral line narrow, white; suprastigmatal space broad, dark brown, usually the darkest band of the body; substigmatal space white, or cream color, shading below.

There is great variation in the color of the larvæ, both in general and in detail. Some specimens are light green, others brownish, and still others cream color. The lines are frequently edged with a shading of another color, making generalizations difficult indeed.

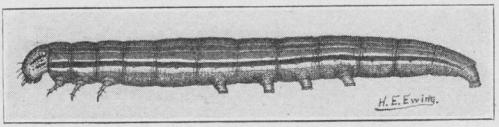
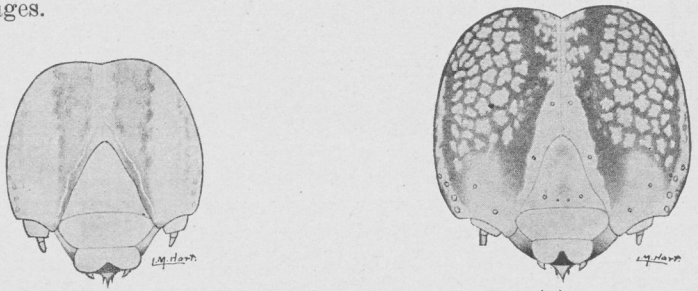


FIGURE 13. THE MATURE LARVA. ENLARGED TWICE

The ratio of increase between head widths of the stages is practically .5, which holds fairly well. The theoretical figures are compared with the averages in the following table.

	Average measurement	Theoretical measurement .5
I	.26	.26
II	.39	.39
III	.65	.58
IV	.96	.87
V	1.55	1.30
VI	2.25	1.95
VII	3.07	2.92

About a month is required for the larva to complete its growth and enter the ground. Not much difference was noticed between the two generations, although egg hatching in the late summer covers a greater length of time than in the spring, and consequently the larvæ are found over a longer time. According to insectary notes the average life of the larva, from the time it hatches to the time it enters the soil, was 29.9 days. One larva, brought in from the field August 22, had the following record. It was stage II August 24; stage III the 26th, stage IV the 29th; stage V September 3; stage VI September 9; stage VII the 19th. It had entered the soil September 27. The time spent in the several larval stages varies, being two or three days in the first three or four stages, and a longer time in the succeeding stages.



(A) (B)

FIGURE 14. FACES OF THE WHEAT-HEAD ARMY-WORM (A) AND THE TRUE ARMY-WORM (B). ENLARGED. (FROM FORBES).

The manner in which the mature larvæ feed has already been described. Cloudy or rainy days seem more favorable for their activity than bright days. They were more easily found on dark days.

THE PUPA STAGE

The mature larva forms a loose cocoon of small particles of earth, spun together with a few strands of silk, in which cocoon it pupates. These cocoons were formed close to the surface of the ground in the summer, usually at the base of a timothy plant.

In the fall they were formed in the same place in the insectary, but we did not find them in the field, although we looked for them several times. Forbes says that the hibernating pupæ are found about six inches below the surface of the soil.

The pupa is described below.

Length 12.8 mm.; breadth 3.9 mm.; average of 10 specimens.

Color dark mahogany brown; abdominal segments above tip of wing sheath finely punctate, the three segments below wing sheath slightly ridged and deeply and irregularly punctate at cephalad portion. Spiracles raised on rounded prominences. Caudal tip black, roughly corrugate, terminating in a bifurcate caudal spine; the two forks fine, recurved, light brown.

Riley said that the length of the pupa stage was 10 to 15 days. In Iowa we found the length to be much longer. Thirty-one days was the average time spent as the pupa, in 16 cases. The range was from 18 to 50 days.

THE ADULT

Following is a description of the moth, by Sir George F. Hampson.

Head and thorax brownish ochreous; antennæ with the shaft white; tegulæ white except the tips, which are brown, and with a brown line near the base often present; abdomen brownish ochreous. Fore wing ochreous; the costal area purplish grey; the veins slightly streaked with brown; a white streak just above median nervure and some greyish and brown below it, with fine black streaks below base and end of cell; claviform very slightly defined by black; a black point on angle of discocellulars; the interspaces of terminal area with very slight brown streaks, rather stronger on each side of vein 5; the termen tinged with purplish grey, with some black points on its inner edge running obliquely to the termen below apex and excurved at middle; cilia ochreous with brown lines through them. Hind wings ochreous white, suffused with fuscous brown except towards base, the veins brown; the underside whitish, with the costal and terminal areas irrorated with brown.

Ab. 1. *obscurior*. Hind wings with the veins and terminal area only suffused with fuscous.

Ab. 2. *neptis*. Hind wing with the veins only fuscous.

Ab. 3. *tetera*. Fore wings more ochreous, the costal area tinged with pink towards apex; a dark streak from discoidal point above vein 5. Arizona.

The moths are commonly attracted to lights. They were easily attracted to a lantern in an infested timothy field. August 8 we set a lantern trap in an infested meadow near Ames between 9:30 and 11 p. m. and many moths were attracted to the light. The night was clear and fairly warm. On the following night, which was clear and cool, the light was tried again, between 8 and 10 p. m., but no moths came to it. When I arrived home at 11 p. m. I found a single moth at the porch light. Apparently the moths are not active on cool nights.

NATURAL ENEMIES

DIPTEROUS PARASITES

Three tachinids were reared from the larvæ. Two of these, *Winthemia quadripustulata* Fabr., and *Euphoracera clarripennis*

Macq., are common species, and have been reared from many other hosts. The first was by far the more numerous and was very abundant in the summer of 1910. The third species, *Metachaeta helymus* Walker, was more rare. It was reared in the fall only. The determinations are by Mr. D. W. Coquillett, through the kindness of Dr. L. O. Howard of the Bureau of Entomology, U. S. Department of Agriculture.

Besides these three Riley recorded another tachinid as parasitic on the wheat-head army-worm. This is *Frontina frenchii* Will.

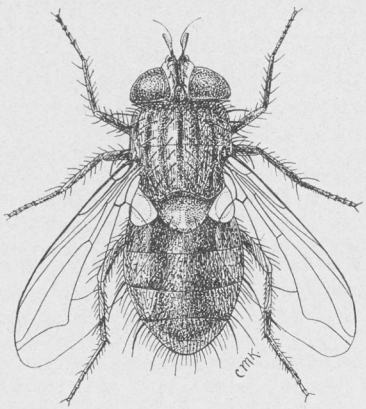


FIGURE 15. WINTHEMIA QUADRIPUSTULATA. A COMMON PARASITE OF THE WHEAT-HEAD ARMY-WORM. ENLARGED SIX TIMES

HYMENOPTEROUS PARASITES

An egg parasite, which has never been previously recorded or described, was found in the summer of 1910. Mr. A. A. Girault, who is our best authority on this group, tells me that this is a new species, and he has given it the manuscript name of *Pentarthron retorridus*. It was first seen August 23 by the writer, when a single specimen was observed ovipositing in eggs of the wheat-head army-worm. Afterwards it was reared abundantly from the eggs, emerging August 30 to September 14.

The hymenopterous parasites of the larvæ were less numerous than the tachinid parasites. Of these *Microgaster auripes* Prov. (H. L. Viereck determination) was the most common. It forms a white, cylindrical cocoon, 6 mm. long by 2.5 mm. broad. This species evidently winters in its cocoon, since many of the cocoons were found in the fall and spent the winter in the insectary.

Another parasite, somewhat less common, was a species of Microplitis, which Mr. Viereck says is new. This parasite affected the younger stages of the larvæ. When it emerged from the host it formed a small brown cocoon, attaching it to the stem on which the host larva was resting.

A secondary parasite was reared from one of these Microplitis cocoons, a new species of Mesochorus, according to Mr. Viereck. One specimen only was reared, this from Grand River, Iowa.

One specimen of *Paniscus geminatus* Say was reared in 1910. (Rohwer determination).

Riley had previously recorded two species from this host, which were not reared here. These were *Anomalon apicale* Cresson and *Ichneumon brevipennis* Cresson. My father, F. M. Webster, writes me that *Apanteles laeviceps* has also been reared from this host by Mr. C. N. Ainslie from larvæ collected in New Mexico.

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